

Inappropriate Anxieties about Crop Protection Residues in Food

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Abstract

Crop Protection Products (CPPs) are a useful weapon in our fight against the pests, diseases and weeds that harm or destroy our food. To be effective CPPs need to exhibit some persistence. The consequence of this is that residues of the original material or its metabolites may remain on food and thus there is a potential for the intake of such residues.

The issue of CPP residues in food is an emotional subject and is rarely debated rationally or supported by scientific facts. Media headlines like “Poison in our food” or “These days enough Pesticides (CPPs) are sprayed onto vegetables to turn you into one” are testimony to the high level of emotion that surrounds the subject of CPP residues in food. Recent surveys of consumers have indicated that more than 80 percent view CPP residues in food as a “serious hazard”. This significantly exceeds concerns over drugs, hormones in meat, nitrates in food, irradiated foods, food additives, or artificial colours.

CPPs are among the most highly regulated of all man-made chemicals, their testing and regulation being equivalent to that of pharmaceuticals. Why is it that the public perception and confidence in the safety associated with residues in food is so negative? The public experience with the food issues over E. Coli, salmonella, listeria, BSE, dioxins and recently the foot and mouth disease in the UK has not helped their belief in the safety of the food they consume. Rather this has led to the view that government scientists and the industry are “sparing” with the facts. Unsubstantiated scares in the past, such as that associated with use of Alar on apples, together with the more recent issue of organophosphates on carrots, have also fuelled consumers concerns on the dangers of treating crops with CPPs.

The benefits of CPPs use on crops needs to be better communicated to the consumer. The public needs to be made aware that the development and subsequent proliferation of CPP use since the 1940s has had a profound social beneficial impact in a number of ways. Today’s consumer expects an affordable constant year-round supply of clean, fresh, healthy and, above all, safe food. It has been well recognised that CPPs not only play a major role in producing food quantity, but also contribute to high quality.

Manufacturers have to demonstrate a wide margin of safety to human health before approval of a CPP is granted by governments. Monitoring data from a large number of countries indicate that CPP residue levels in food are extremely low; thus providing even stronger evidence that our food is safe. Regulatory law provides for the safety of food. Residues in food are not permitted unless they are proven to be safe at the highest levels of exposure anticipated. It is interesting to note that the potential of naturally occurring CPPs in food to harm human health is higher than the risk from Regulatory approved man-made CPPs. There

are rigorous testing and regulatory programmes for man-made CPPs, and only minor *ad hoc* programmes for natural CPPs; thus, we have dual standards.

This paper deals briefly with the benefits and alternatives to CPPs use along with methodologies used for safety assessments, which ensure that the consumer is not exposed to any risk from man made CPP residues in food.

Introduction

Crop Protection Products (CPPs) are chemicals, both man-made (synthetic) and naturally occurring, that control the diseases, insects and weeds which harm or destroy our food. The man-made ones can be thought of as “medicines for plants” which are only needed when naturally occurring CPPs made by the plant do not work well enough. It is not always realised that a plant’s response to attack is to produce phytotoxins - their own in-built natural CPPs. In reality 99.99% of all CPPs are found naturally in plants and only 0.01% are man made.⁽¹⁾

It is estimated that 30-40% of the world’s food crops are destroyed annually, despite the use of CPPs.⁽²⁾ Furthermore, in the light of the estimates for continued world population growth and the recognition that the world’s remaining natural ecosystem should be protected in the face of competition from development for housing and cultivation for increased food production, CPPs will remain essential for the foreseeable future.

The presence of CPP residues in food in relation to human health is the subject of a constant debate between the agrochemical industry, the scientific community, government regulators and consumers. The public is confronted almost daily with media headlines that report how some factors in their daily life are hazardous to their health, most of which they are powerless to avoid, e.g. natural toxins in food, passive smoking, car exhaust emissions etc. As a result, the public is naturally confused and consequently concerned. Therefore, it is not surprising that some consumers feel that CPP residues in food are unnecessary and preventable types of contamination. With this volatile issue, it is important to maintain the facts and concerns in a proper perspective. Increased transparency supported by industry and policy makers is likely to improve public credibility. An effective risk-benefit communication needs to be provided to allow the consumer to make informed choices. We need to look at ways of “gaining consumer confidence” by providing simple, clear explanations and assurance about their concerns.

Natural Crop Protection Products in Food

Nature has given plants their own in-built natural defence mechanism against insects and diseases. Clearly natural toxic materials are widespread, albeit in small amounts. These are normally insufficient to cause a health problem. However, some of them such as glycoalkaloids approach danger levels in plants. Indeed, over 80 different glycoalkaloids have so far been identified and they occur in plants at variable levels.⁽³⁾ These materials have been responsible for outbreaks of acute gastrointestinal illness and even occasional fatalities.⁽⁴⁾ Another example, Psoralens, a group of naturally occurring CPPs in parsnip, celery, parsley and related vegetables are carcinogens and are often present at up to 100 mg/kg.⁽⁵⁾ In many foods, significant toxic chemicals may be present and, in some cases, they can exceed levels that would be regarded as unacceptable were they to be added to food products. Certainly there is no 100-fold safety margin as is mandatory in the case of man-made CPPs.

There is increasing evidence that mycotoxins pose potential hazards to human. There are more than 400 substances known as mycotoxins with toxic effects to human and warm-blooded animals, which belong to a large number of chemical classes.^(6,7) Mycotoxins can develop both during the actual growing period of the crops as well as in storage. Processing does not destroy or remove these toxins, thus man-made CPPs must be directed towards their

prevention. The main intake of mycotoxins occurs via cereals and its products, oil seeds, nuts and coffee. There is ample information available on the presence of mycotoxins in different commodities. Some countries have been forced to impose limits on concentrations of mycotoxins in food and feed. Data on mycotoxin contamination have shown that this is a widespread problem concerning food supplies in some countries.

The level of human exposure to natural CPPs is not known and there seems to be an absence of public awareness of this risk. Potatoes are natural and so must be healthy! The public know vaguely that they should not eat the green part of potatoes - but, in practice, the green parts are only removed because they do not taste nice. It is lucky that solanin tastes unpleasant since toxic levels are easily reached. The notion that a natural toxin, by virtue of occurring naturally, is somehow better or safer is hardly logical.

Benefits of Man Made Crop Protection Products

The public outside the agricultural arena associates the use of CPPs only to protect crops from insects, weeds and fungal diseases in order to maintain yield. The overall objective of modern agriculture is to provide a steady and sufficient supply of high quality, healthy and safe food and feed at affordable prices in a sustainable manner.

The key benefits of CPPs are: -

a. Food Security

CPPs secure yields in the field and reduce crop losses during storage, thus helping to meet global food demand. They are essential in preserving stocks of staple foods such as rice and cereal grains. Without their use yields will fall by 50 percent.⁽⁸⁾

b. Health Benefits

CPPs contribute towards the supply of high quality fruit and vegetables at affordable prices. Positive health benefits are well acknowledged from regularly eating fresh, healthy fruit and vegetables. There is evidence that vector-borne diseases and disease-bearing insects can be controlled successfully by the use of CPPs.

c. Environmental Benefits

The use of CPPs in minimum or no-tillage systems has contributed in reducing soil erosion, thus preserving land, natural habitat and biodiversity. The increased crop yield obtained by efficient farming ultimately preserves natural habitats by reducing the demand for more agricultural land.

d. Social-Economic Benefits

Integrated Crop Management (ICM) strategies provide alternative technologies that allow farmers to reduce CPP inputs while maintaining productivity and profitability. Food is therefore produced at low cost, providing affordable food for all.

It is generally accepted that crops must be protected from pests and diseases and kept free from competition with weeds in order to avoid considerable yield and quality losses. Fungal diseases like head blight of wheat caused by fusarium do not only reduce baking quality but

also lead to losses of protein, starch and of general nutritional value of the cereal grain. Rye and wheat ergot are caused by fungal spores in these cereals and have been a major problem since medieval times. The toxic alkaloid in bread causes serious health problems and can lead to death. The contribution of modern CPPs and production methods had virtually eliminated this problem until recently, when alternative agriculture has led to a certain renaissance of ergot occurrence in foodstuffs. Mycotoxins, such as aflatoxins, which occurs in peanuts, maize and animal fodder belong to the strongest known naturally occurring carcinogens and man-made CPPs are effective in controlling them.

Alternatives to Man Made Crop Protection Products

Organic food has been presented as a viable alternative to modern farming and CPP use and there has been a significant interest and consumer demand, particularly in some countries in Western Europe. A recent survey by the UK Consumer Association indicated that consumers who purchase organic food do so for the following reasons: -

- The belief that organic food contains no CPP residues and thus is safer
- A perception that organic food tastes better than conventional food
- Protection of the environment as application of CPPs are a danger to the environment and people

It is now becoming recognised that organic farmers do use some fertilisers and CPPs such as copper and sulphur for pest and disease control. However, the substantial avoidance of the use of modern CPPs brings into question how “organic” food will be protected from pests and disease infestation during growing and under storage conditions! The real question to be addressed is “**can organic farming supply and sustain both the quality and quantity of food at affordable prices globally**”? High yield farming is feeding twice as many people as the planet supported in the 1950s, and feeding them better diets, without using more cropland. The food challenge for the 21st century is to triple world farm output again by the year 2050, with less impact on wildlife habitat than farming today. High yield farming is the only viable strategy for meeting this challenge. It is estimated that without high yield farming we would need to cultivate an extra 15-16 million square miles, the land area of the western hemisphere with far reaching consequences for the world’s ecosystem.

There is no proven evidence that organic food tastes better. In fact, recently the UK Advertising Standards Authority (ASA) gave a ruling that effectively bans the advertising of organic produce as any healthier, tastier or better for the environment than conventional alternatives. Approved CPPs do not threaten wildlife. There is never much wildlife in a crop field, organic or not. It is the billions of wild organisms that thrive in the two acres left unploughed which is important to preserve and protect. Organic farming cannot provide sustained quality and quantity of food globally due to its low yield. If we plan to depend on organic farming, we would need to cultivate another 15-16 million square miles of land and thus eliminate masses of wildlife.

New disease-resistant varieties of crops are being produced using biotechnology. It is clear that the application of biotechnology in this area must be approached with caution if the public are to accept the advances that are now possible.

Perception of Risk and Hazard

Some people think of risk and hazard as one and the same and it is important to understand the difference. The hazard potential of any CPP is determined by its toxicity. Risk, on the other hand takes into account the predicted level of exposure and the likely effect at that level of exposure. For example, a single dose of 10 g of caffeine is enough to kill an adult, however that is equivalent to drinking 75 cups of black coffee in one single sitting. Therefore, it can be seen that caffeine is in fact a hazard, but the risk to health due to consumption of coffee is in fact negligible as our everyday experience confirms. It is unfortunate that within European Union the regulation for labelling chemical substances use the term “risk phrases” that describe the hazard, but not the risk.

The risk perceptions of the public are influenced by the way individuals view the world and their attitude is heavily influenced by their own ability to control the risk.⁽⁹⁾ In fact, perceptions of risk may be lifestyle-related. If people underestimate personal risks, they may not take appropriate steps to reduce their exposure to the hazards. For example, individuals believe that they can control their intake of alcohol or fat so that they are regarded to be acceptable risks. However, CPP residues are outside their control and are thus perceived as high risk. As sufficient food supply is today nearly guaranteed for the entire population of developed countries, and is available for the decreasing share of a household's income, the willingness to accept related risks is decreasing. People tend to have some very general views that the excess of food supply is coming from the increasing economic strength of the country they live in. Factors like modern farming practices, with the use of CPPs are easily forgotten, behind the indisputable benefits of strongly improved distribution channels.

Assessing the Risk to Consumers

During the CPP approval, process the potential exposure of consumers to residues in food is carefully assessed. The safety of CPPs is measured by assessing the **risk**, which is determined by the two components: **exposure and hazard**. In order to measure exposure, we need to know two things: -

- Amount and type of food we eat which is available from national surveys.
- Amount of residues in food.

The output from residue studies provide data which is used to calculate maximum residue levels (MRLs) or tolerances.

It is important to understand that MRLs are trading legal limits and they enable government regulators to check that CPPs are not being misused. MRLs should not be confused with safety limits and exposure to residues in excess of MRLs does not automatically imply a risk to health. The term MRL is confusing to both the consumer and the food industry, and it is high time to change such as Legal Trading Limit (LTL) as it is used for trading purposes mainly.

Safety limits are expressed in terms of the Acceptable Daily Intake (ADI) of a particular CPP residue from all sources. Approvals are only given if the ADI is not exceeded from an unusually high level of exposure. The ADI is defined as the amount of a chemical, which can

be consumed every day for an individual's entire lifetime in the practical certainty, on the basis of all known facts, that no harm will result. The ADI is derived from a wide range of studies on the CPP and incorporates a "safety factor", which is typically 100, applied to the dose level producing no adverse effects in the most sensitive study. The factor is to allow both for uncertainties in extrapolating from results in experimental animals to human exposure and variations in susceptibility within the human population.

Long Term Exposure

In 1997, the UK updated its modelling with respect to long term intakes by introducing the recommendations of the WHO.^(10,11) It was recognised that the tiered approach of the theoretical maximum daily intake (TMDI) was too prescriptive and was a gross overestimate of actual exposure. Recently, a more refined intake calculation was provided by the international estimated daily intake (IEDI) and the national estimated daily intake (NEDI). This allows refinements such as losses during routine cooking and processing to be taken into account at the first stage of calculation. The NEDI is calculated for adults, children, infants and toddlers. Instead of using the MRL, the supervised trial median residue (STMR) is used which is a more realistic reflection of the residue level to which consumers are likely to be exposed during their entire lifetime. The NEDI still represents an overestimate because of the assumptions made such as:

- Consumption level of 97.5th percentile (which is "high level" consumption) will be maintained throughout the entire lifetime of the consumer.
- All crops listed for registered uses are treated with the CPP at the maximum rate, number of applications and harvested at the shortest pre-harvest interval recommended on the label.

Exposure calculations that are done in EU member states differ significantly in the selection of typical or most sensitive consumer groups. It is most desirable that harmonised diets reflecting habits of the main consumer populations are developed and that calculation models are harmonised to create transparency for the consumer to increase their confidence in these risk assessments. Monitoring data generated by national countries should be used for more realistic intake calculations since samples are usually taken at retail outlets and are more representative of the general food supply.

Short Term Exposure

Concern has been expressed about exposure to residues of acutely toxic CPPs where the residues in a single item exceed the MRL. MRLs are trading standards and they are derived from composite samples rather than individual crop items. It is recognised that analysis of composite samples still offers the most appropriate means of ensuring that traded commodities do not contain unacceptable levels of pesticide residues. However, the UK PSD (Pesticide Safety Directorate) work on carrots (see the Working Party's 1994 annual report) indicated that the variation in residue levels between individual roots in a single crop can be high. This phenomenon has been observed on other crops such as apples, pears, peaches, oranges and tomatoes etc.⁽¹²⁾ There is no firm evidence as to why the range of variation should be high. Nevertheless, acute assessment has been developed to take account of residue variation from item to item of a food. Such variation would only be of significance if the CPP concerned:

- Has high toxicity at a low dose; and
- Is consumed in a significant amount in a single meal

The acute dietary exposure is compared with the `acute reference dose` (acute RfD). The non-probabilistic or deterministic, approaches used in some EU member states usually overestimate exposure in order to protect high-level consumers. The probabilistic modelling approach to acute dietary exposure has been developed and is used in the USA. It is currently not used on a routine basis in Europe and EU member states and should be adopted as soon as possible since it provides more realistic estimates of both the likelihood and magnitude of dietary exposure levels. The methodology for assessing acute dietary exposure continues to be developed at national, EU and the FAO/WHO. This will not only take account of short-term intakes but also variability of residues between item to item of a food.

Both long and short-term dietary exposure assessment requirements in the US are similar to those in Europe and WHO. However, there are some differences due to the introduction of Food Quality Protection Act (FQPA). These are: -

- Additional protection for children and infants by the use of an additional safety factor
- Aggregate assessments of risk of a single CPP from total exposure from all sources (non-occupational + residential)
- Cumulative risk from multiple compounds with the same mode of action.

Conclusions

Man-made CPPs are among the most highly regulated chemicals, their testing and regulation being equivalent to that of pharmaceuticals. They have a number of benefits ranging from healthy food supply to security of crops of high market value. The public is not fully aware of natural toxins in our food and think differently about man-made and natural CPPs.

Farmers generally use CPPs very judiciously. CPPs are one of the most expensive “inputs” that a farmer can use. Man-made CPPs are “medicines for plants” and only needed when it is anticipated that the threshold level for unacceptable economic loss in the yield is exceeded. The emphasis on ICM strategies has strengthened this point.

Manufacturers are obliged to demonstrate wide margins of safety from residues in food as far as human health is concerned for both short and long term exposure. Regulatory authorities independently assess the safety of the CPP before approval is granted. National government monitoring programmes indicate that consumers through dietary intake are exposed to a small fraction of the dose that has been deemed to be safe. This fact supports the hypothesis that current models for consumer exposure assessments are overcautious and, that obviously, good agricultural practice as recommended on the product label is widely respected. The latter is certainly not only driven by pure economic factors, it is certainly the result of a change in the thinking of growers and the food industry who have realised that consumers demand agricultural products with minimum residues in food. It is clear that industry and national governments have to continue to take human safety and monitoring of CPPs in food very seriously. The fact that occasional high residues are detected confirms that surveillance schemes are working in the interest of the consumer.

It is important to recognise that MRLs are trading legal limits and they enable government regulators to check that CPPs are not being misused. Primarily MRLs are not health standards and exposure of residues in excess of MRLs does not automatically imply a risk to health. The term MRL is confusing to both the consumer and the food industry and it should be changed to a more appropriate term to reflect its purpose, such as Legal Trading Limit (LTL).

The development of new methodologies for dietary exposure assessments will lead to more realistic estimates. However to allow consumers to understand that CPPs are safe for them and their children, it is important that governments invest in regularly updated internationally comparable surveys on dietary intakes, that take the changing eating habits of population into account. Only when these data are available, can realistic exposure estimates be made.

Man-made CPPs play an important role in delivering the benefits of cheaper, better quality, safe food that is available all year round for a large part of the global population.

In my opinion, worrying about well-tested small traces of residues in our food is more harmful to health than the traces of residue itself. The fact is that the benefits of CPPs are far greater than any possible risk of their residues in food. Today we know more about food and our food is safe. There is no alternative to high yield farming and improved storage conditions for harvested produce to meet the need for increasing food supply during the coming decades. The use of CPPs alone is certainly not the only factor to meet that goal, however according to our current knowledge it will be an indispensable element to meet the food production challenge of the 21st century.

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*A & N Consulting is an independent group of scientists with extensive industrial experience, gained in a major agrochemical company (Syngenta), providing expert advice on hazard and risk to the food and agrochemical industries.